

Performance Characterization of a 42.65Gbit/s Dual Gate Asynchronous Digital Optical Regenerator Using a Single MZM

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Abstract: We experimentally demonstrate the tolerance of a 42.65Gbit/s dual-gate asynchronous digital optical regenerator using a single Mach-Zehnder modulator to optical signal-to-noise-ratio degradation and chromatic dispersion.

Introduction: The continued exponential growth in traffic demand of both home and business users, currently driven by video down-streaming applications, results in an increasing demand for higher-bandwidth connections. To meet this need, access and metro core networks capable of handling traffic at higher capacities and different speeds are required [1, 2]. Therefore efficient interconnection of access, metro-core and backbone networks operating at different line rates is needed in future networks [3, 4]. For this type of data aggregation, synchronization between merging streams is required, and is traditionally performed by electronic buffer stores. For burst mode traffic, however, an Asynchronous Digital Optical Regenerator (ADORE) allows the simultaneous regeneration and retiming of incoming data bursts with arbitrary phase to that of an individual locally generated clock [1, 3]. A number of variations on the ADORE architecture have been reported [6], including interferometric configurations [4], and the use of radio-frequency (RF) phase detection as a simplified method for optimum delay-path selection [5]. The experimental implementation of a dual-gate ADORE using a single optical modulator, which performs asynchronous retiming, pulse width adaptation, regeneration and wavelength conversion, has been demonstrated previously [5, 7]. In this paper we characterize the performance of a 42.5Gbit/s dual-gate single-modulator ADORE as a function of optical-signal-to-noise ratio (OSNR) and chromatic dispersion (CD).

Experiment: The ADORE (figure 1a) detected an incoming data signal and used this to drive a single Mach-Zehnder modulator (MZM) configured to act as an optical dual-gate. To achieve signal regeneration, the ADORE also contained a continuous optical pulse-train source driven by a local free-running oscillator, and this optical clock was sampled by the modulator. A simple RF phase comparator circuit was used to measure the phase difference between the incoming data and the local optical clock pulses, and this phase-difference signal was used to select the optimum sampling clock phase using a 2×1 electro-optic switch with a 400ns switching time [5]. The regenerated signal at the output of the ADORE had the same pulse width and wavelength characteristics as the local optical clock, and was also synchronised to the local clock independent of the incoming data phase [5].

Figure 1b shows the experimental setup for measuring the characteristics of the ADORE under different OSNR and CD conditions. Using an external cavity laser (centered at 1558.7nm) and two MZMs, a 42.65Gbit/s 33% RZ-ASK data signal was generated with a pseudorandom binary sequence length of 2^7-1 , and back-to-back receiver sensitivity of -32.2dBm (for a 10^{-9} bit error rate) was measured. This signal then passed through a variable optical delay, which allowed the relative delay (d) between the data signal and the local clock to be varied. This was followed by various lengths of standard single mode fibre (SMF) (group-velocity dispersion of ~ 17 ps/nm/km) to introduce controlled amounts of CD, and a variable optical attenuator together with an erbium-doped fibre amplifier (EDFA) to set the OSNR. The total optical power was then restored to a fixed level using a second EDFA and variable attenuator, and this signal was launched to the ADORE setup. The OSNR at the input to the ADORE was measured at the output of the first EDFA. The receiver sensitivity of the ADORE output, i.e. the regenerated RZ-ASK signal, was measured for different settings of the delay d , OSNR and CD.

Results: Figure 2 shows the measured receiver sensitivity versus different values of the relative delay d , with 40dB OSNR and zero CD. As shown, the automatic operation of the 2×1 electro-optic switch in the ADORE ensured error-free performance over a range of d values, corresponding to more than one bit period (23.4 ps). The receiver sensitivity penalty for the RZ-ASK regenerated signal was 1dB at the optimum value of d , with an additional 2dB penalty at the worst-case value. As shown in the eye diagrams, the sensitivity penalty variation may be

attributed mainly to degradation in the extinction ratio corresponding to small levels of signal leakage from adjacent bit slots when d is set to the worst-case value, owing to the finite rise and fall times of the gate switching window. In addition, the receiver sensitivity was measured with d set to the worst-case value and with the 2×1 electro-optic switch set manually to both configurations separately; thus by observing that the sensitivities were the same (within 0.4dB), this verified that the automatic switching occurred at the correct value of d .

Figure 3 shows the performance of the dual-gate ADORE versus input OSNR. The double-oval headed arrows indicate the range of measured receiver sensitivities from the worst-case value of d (top) to the best case (bottom). These results confirm that the ADORE can operate error free with automatic switching over a wide range of OSNR. Error-free operation was observed for an input OSNR above 26dB for all values of d , and the receiver sensitivity variations with d were <3dB for OSNRs above 30dB.

The CD tolerance of the dual-gate ADORE, measured at 40dB OSNR and with automatic switching enabled at the worst-case value of d , is shown in figure 4. The additional penalty due to dispersion was <1dB up to 16ps/nm and 9ps/nm of dispersion for the best-case and worst-case values of d respectively, with the 33% RZ-ASK input.

Conclusions: In this paper we characterized a dual-gate single-modulator ADORE with RZ-ASK data signals at 42.65Gbit/s, showing a receiver sensitivity variation of ~2dB with automatic channel selection for an input signal with 40dB OSNR and zero dispersion. It was shown that the device operates automatically without errors over the full range of relative phases between the input signal and local clock. This ADORE can tolerate input OSNR degradation to 30dB and 14ps/nm CD for a 3dB receiver sensitivity variation between best and worst-case values of the relative phase. It offers a practical solution for retiming burst or packet-switched optical data signals at gateway interconnections between networks.

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Figure captions:

Fig. 1a Experimental setup of 42.65Gbit/s dual-gate ADORE using a single MZM

Fig. 1b Experimental setup for OSNR and CD characterization of dual-gate ADORE

Fig. 2 Variation in receiver sensitivity as a function of input data phase delay

Fig. 3 Variation in receiver sensitivity as a function of input OSNR.

Fig. 4 Variation in receiver sensitivity as a function of input chromatic dispersion

Figure 1a

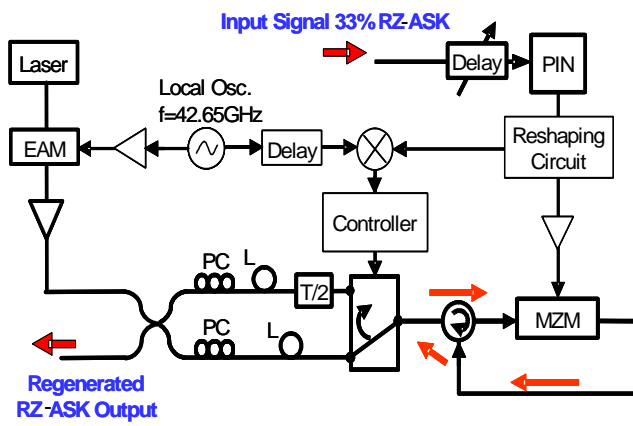


Figure 1b

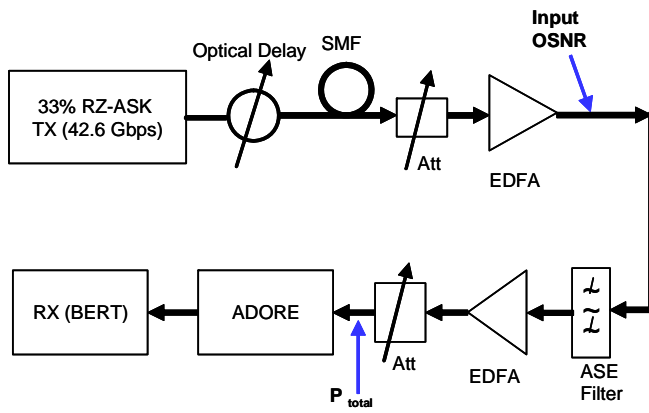


Figure 2

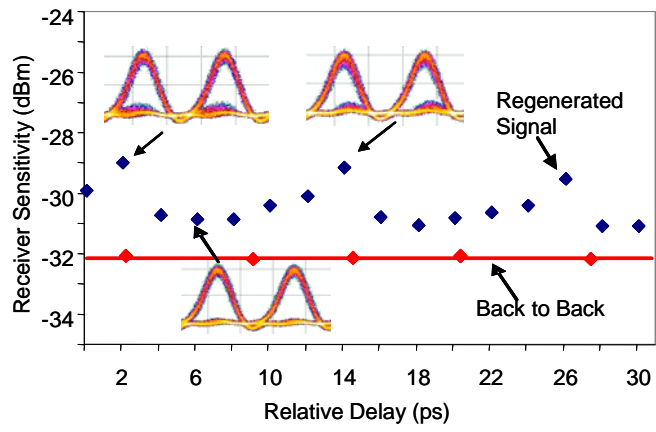


Figure 3

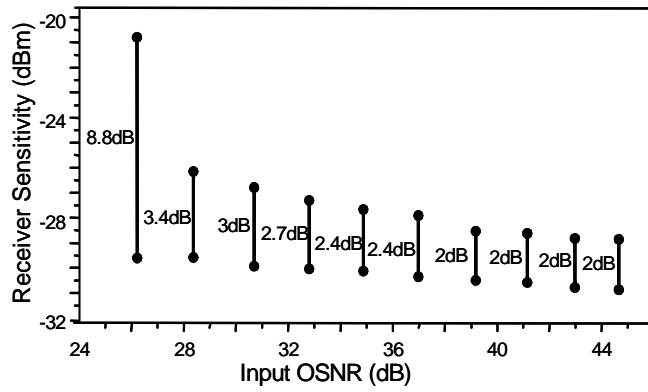


Figure 4

