A System Perspective of All-Optical Digital Logic Gates

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Abstract: *This presentation will review results from the recently completed European Commission funded project DO_ALL on digital all-optical logic processing. The purpose of the project was to identify and demonstrate the necessary modules required to perform all-optical signal processing and to combine them to show non-trivial logical functionality.*

During the past ten years photonics technologies have gone through an unprecedented improvement that has resulted in their widespread up-take and market penetration. Over the years all-optical signal processing has been the goal to attain for a large number of researchers and it seems that as a result of technology maturity it may now be closer to realize than ever before.

Even though general purpose all-optical processing is still a long way off, low complexity but non-trivial, circuits that can perform on-the-fly computation at high data rates are now a technical reality and may indeed be of commercial interest in telecoms networks so as to avoid conversions between the optical and electronic domains. However for commercial interest in all-optical signal processing to materialize, high performing and low cost processing units are a pre-requisite. For technology developers to adopt all-optical signal processing solutions, it is also necessary for optical circuits to be commercially available and readily integrable so as to perform non-trivial processing tasks.

In view of this rationale, the purpose of the DO_ALL project (Digital OpticAL Logic Modules) was to identify and demonstrate the necessary basic optical units necessary to perform optical logic and to combine them to show non-trivial functionality in two application experiments. As basic optical units we have defined, high speed laser sources, optical amplifiers and optical gates, while necessary support optical subsystems are clock recovery and synchronization circuits, optical buffers and optical sampling units. Within DO_ALL these circuits were assembled and integrated to show (a) an optically addressable exchange-bypass switch and (b) optical error rate measurements as application experiments for the following reasons. It can be shown that an optical exchange-bypass switch can be built with a single optical gate while a corresponding electronic design requires 8 Boolean gates and this application experiment underlines functionality advantages that may be achieved by using all-optical techniques. All-optical error rate measurements were chosen as the second application experiment because the circuit required is important to show, logically simple but of high optical complexity. As such this experiment was designed to demonstrate the ability to integrate a number of optical gates into a circuit.

In this presentation we will review the main technical achievements of the DO_ALL project and we will highlight practical difficulties and solutions that they have emerged during the course of the project.

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